King County Tabula: Task 1-Unit Cost Update

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This memo pertains to Work Order #9 of King County Wastewater Treatment Division for revisions and updates to their "Tabula" Cost Estimating Program. Specifically, this memo discusses Task 1, Revise/Update Existing Wastewater Capital Construction Cost Estimates.

This memo is a submittal of findings and recommendations for updating unit costs within the Tabula program. Once King County has had an opportunity to review these recommendations, a meeting will be held to discuss and come to an agreement on whether or not to accept the recommendations. Accepted changes will then be made by CH2M HILL to the Tabula program.

Even after the changes have been made to Tabula, this program will remain a parametric estimating tool. The estimates produced by Tabula will be Class 5 or Class 4 estimates as defined by the Association for the Advancement of Cost Engineering (AACE)[1]. Therefore, appropriate contingencies must be applied to the resulting estimates from the Tabula program in order to develop adequate planning level budgets.

In addition to contingencies for unknown project scope definition, in the upcoming months and possibly years, attention must be given to the recent effect on the construction industry of hurricanes Katrina and Rita in the gulf coast region. Opinions vary on what that effect might be in the northwest region. Davis Langdon & Seah International states that their opinion is that "non-residential construction will be effected less than 5% nationally". In *Engineering News Record*, September 26, 2005 issue, the Atlanta-based program manager Boyken International, Inc. is quoted as saying "that estimates it is using over the next six months include 10 to 15% increase in home-related materials and 8 to 10% increases in commercial building materials". And "The combined higher labor and materials cost will result in a 15% rise in the cost of construction on all projects". The largest concern that may

[1] AACE defines a Class 5 estimate as an estimate preformed at the 0-2% level of design and has an expect accuracy of <+50% to <-30%. This class of estimate is used primary for screening or feasibility studies. A Class 4 estimate is an estimate developed at the 1% to 15% level of design and has an expected accuracy range of +50% to -30%. This class of estimate is used primary for conceptual of feasibility studies. Both Class 4 and 5 estimates are also known as Order of Magnitude estimates.

impact the northwest is the potential risk of unknown future material prices and availability which will lead to higher bid prices. An additional contingency should be added to account for this issue in the range of 5% to 15% to be adjusted based on actual local impacts for the foreseeable future.

This memo explains the process of updating the unit costs contained in King County's Tabula estimating program. The unit costs contained with this program were established by HDR in December 1999 and have not been updated since then. King County has contracted CH2M HILL to examine the unit costs contained within the program and compare them with current construction costs and, where necessary, recommend new costs to reflect the existing construction market.

In general, several sources of information were used to develop these new cost units: bid tabulations from Washington State Department of Transportation (WSDOT), Seattle Public Utilities (SPU) and other various local agencies; vendor material quotes; contractor information; King County prevailing wage rates to develop labor costs when necessary; and *RS Means 2005 - Heavy Construction* information adjusted for King County wage rates. How these sources were used is explained in greater detail under the explanation of the various unit costs were developed.

Section 1: Pipeline Cost Information

The "Fixed Input Parameters" were compared against a variety of cost sources. Trench shoring was compared against recent WSDOT bid tabs and several recent jobs. It should be noted that the program calculates the SF unit area as the exposed sides of the trench while WSDOT bid tabs uses the SF area of a single plane down the center of the trench (WSDOT Standard Specification 2-09). Thus WSDOT bid tab costs need to be divided in half in order to calculate the exposed trench side costs. Special shoring can pertain to a variety of shoring alternatives. For purposes of comparing cost three systems were compared: steel sheets with jacks, trench slide rail shoring rental systems, and sheet piles. Sheet pile costs were developed from RS Means using King County labor rates. The slide rail shoring system costs were developed through vendor experience for systems used in the greater Seattle area and current rental rates. Also WSDOT bid tabs were examined to compare against.

Earthwork costs were developed by comparing RS Means costs using King County labor rates, WSDOT bid tabs, SPU unit costs, and vendor costs for imported backfill material costs. When comparing bid tabs it should be remembered that hauling and disposal of extra excavation is rolled in the WSDOT and SPU costs.

Asphalt concrete pavement (ACP) paving costs were collected from WSDOT Bids Tabs, recent quotes from ICON and Wilder Construction, SPU unit cost, and other projects that have recently bid. For patching the cost is based on a 6" thickness which is the indicated depth on the trench geometry profile in the Tabula report. Pavement removal and sawcutting are also included in the pavement patching costs. Cost for overlays outside of the trench patching area costs are based on a 2" overlay depth which a typical depth seen in construction projects. The cost for grinding and pavement re-striping is included in the overlay costs.

Tabula uses the *Engineering News Record*, Construction Cost Index (ENR CCI) for the means to adjust historical costs to current costs. CH2M HILL confirms the use of this index

because it is based on the Northwest regional construction economy and it is a widely used for this purpose in the construction industry. September 2005 (8390 ENR CCI) was selected as the current dollar index.

Below is a summary of the "Fixed Input Costs" currently used in the Tabula Program expressed in December 1999 dollars (ENR CCI = 7,137). The table also indicates CH2M HILL recommended for unit costs based on our cost comparisons to the above sources in September 2005 dollars (ENR CCI = 8,390). See the Appendix A for cost information details.

Table 1. Fixed Input Parameters

Items	Units	Current Tabula Unit Cost (Dec 1999 Dollars)	Escalated Tabula Unit Cost (Sept 2005 Dollars)	Recommended Unit Cost (Sept 2005 Dollars)
Mob/Demob	LS	10%	10%	10%
Trench Safety (Box)	SF	$0.50	$0.59	$0.50
Special Shoring	SF	$8	$9	$12
Excavation	CY	$10	$12	$12
Imported Backfill	CY	$25	$29	$32
Place Backfill	CY	$5	$6	$8
Spoil Load & Haul	CY	$10	$12	$12
Asphalt Paving (Trench)	SY	$50	$59	$55
Asphalt Paving (Beyond Trench)	SY	$20	$24	$25

Tabula currently uses three types of pipes for costing purposes. Class V reinforced concrete pipe (RCP) for gravity sewer, Class 53 Tyton Joint ductile iron pipe for force mains, and restrained joint ductile iron pipe for force mains with high head applications. Cost quotes for the various pipe materials were obtained from local area vendors. Pipe installation production rates and crew sizes were taken from RS Means. King County labor rates were used to calculate installation costs for the various pipe sizes. For RCP a 2% markup was added to the material cost for testing, miscellaneous connections, etc. On the ductile iron force mains a 15% markup for fittings, connections, cathodic protection, valves, blow offs, air release valves (ARVs), testing, etc. This is based on similar sewer force main percentages seen on other projects. A similar 10% markup is placed on installation costs to account for these additional pipe costs. These costs were then compared to various bid tabs. See the Appendix B for cost information details.

Table 2. Pipe Material and Installation Costs

	Current Tabula Costs (Dec 1999 Dollars)				Escalated Tabula Cost (Sept 2005 Dollars)				Recommended Costs (Sept 2005)			
Pipe Dia (in)	Force Main Pipe Material Cost ($/LF)	High Head Force Main Pipe Material Cost ($/LF)	Gravity Sewer Pipe Material Cost ($/LF)	Install Cost ($/LF)	Force Main Pipe Material Cost ($/LF)	High Head Force Main Material Pipe ($/LF)	Gravity Sewer Pipe Material Cost ($/LF)	Install Cost ($/LF)	Force Main Pipe Material Cost ($/LF)	High Head Force Main Material Pipe ($/LF)	Gravity Sewer Pipe Material Cost ($/LF)	Install Cost ($/LF)
8	11	15	10	10	13	18	12	12	18	24	8	18
10	14	20	12	12	16	24	14	14	24	31	10	20
12	18	25	15	15	21	29	18	18	30	38	16	24
14	23	32	NA	18	27	38	NA	21	38	50	NA	24
15	NA	NA	18	20	NA	NA	21	24	NA	NA	17	24
16	26	38	NA	22	31	45	NA	26	45	59	NA	26
18	30	44	23	25	35	52	27	29	52	68	22	27
20	35	50	NA	26	41	59	NA	31	58	78	NA	29
21	NA	NA	26	27	NA	NA	31	32	NA	NA	24	30
24	43	65	30	30	51	76	35	35	73	98	32	36
27	NA	NA	36	35	NA	NA	42	41	NA	NA	49	51
30	80	110	50	40	94	129	59	47	105	139	60	53
36	108	150	60	54	127	176	71	63	145	191	73	65
42	140	185	78	60	165	217	92	71	196	250	95	70
48	200	240	105	72	235	282	123	85	260	310	121	79
54	250	315	150	100	294	370	176	118	340	410	151	97
60	315	390	190	120	370	458	223	141	400	470	210	105
72	NA	NA	240	160	NA	NA	282	188	NA	NA	270	126
78	NA	NA	280	180	NA	NA	329	212	NA	NA	320	140
84	NA	NA	360	200	NA	NA	423	235	NA	NA	380	158
96	NA	NA	440	240	NA	NA	517	282	NA	NA	490	210
108	NA	NA	540	280	NA	NA	635	329	NA	NA	610	315
120	NA	NA	720	360	NA	NA	846	423	NA	NA	740	420
144	NA	NA	1050	480	NA	NA	1234	564	NA	NA	1300	505

Manhole material costs were established by obtaining a vendor quote for the manhole sections. Manhole depths were calculated based on 12 feet of cover for the pipe as stated in the HDR *Task 250 Report*. Different sized manholes are used depending on the pipe size. The largest pipe diameter indicated in each manhole range was used to calculate the final invert depth. For manholes with greater than 12 feet of cover an additional cost to add sections to the manhole was developed. These costs are in additional vertical linear feet of depth (VLF). Installation cost were developed using the crews based on King County wage rates. These calculated rates were then compared to WSDOT Bid Tabs, SPU Unit Cost and RS Means costs for similar sized manholes. See the Appendix C for cost information details.

Table 3. Manhole Sizes and Costs

Manhole Diameter	Pipe Diameter Range	Current Tabula Base Cost ($/each) (Dec 1999 Dollars)	Current Added VLF Cost ($/VLF) (Dec 1999 Dollars)	Escalated Tabula Base Cost ($/each) (Sept 2005 Dollars)	Escalated Tabula Added VLF Cost ($/VLF) (Sept 2005 Dollars)	Recom-mended Base Cost ($/each) (Sept 2005 Dollars)	Recom-mended Added VLF Cost ($/VLF) (Sept 2005 Dollars)
48	<21	3000	250	3500	290	4000	290
54	24-27	5000	300	5900	350	5000	430
72	30-42	9000	500	10600	590	9500	900
84	48	12000	700	14100	820	14000	1300
96	54-60	16000	900	18800	1060	18000	1500
108	72	20000	1200	23500	1410	22000	1900
120	78	26000	1600	30600	1880	29000	2200
144	84-144	32000	2000	37600	2350	36000	2600

Right-of-way costs were examined by two methods. Detailed right-of-way costs were worked for the SR 520 project along the SR 520 corridor by WSDOT Real Estate Services. These costs included urban and suburban residential costs and commercial properties. Also changes in property values in King County from 1999 to 2005 were examined. Using this information a percent increase in property values from 1999 was established and that percentage was applied to the 1999 Tabula costs. By comparing data from these two efforts a recommended land value cost was established. See the Appendix D for cost information details.

Table 4. Right-of-Way Acquisition & Easements

Area	Current Tabula Property Acquisition Cost ($/SF) (Dec 1999 Dollars)	Current Tabula Permanent Easement Cost ($/SF) (Dec 1999 Dollars)	Escalated Tabula Property Acquisition Cost ($/SF) (Sept 2005 Dollars)	Escalated Tabula Permanent Easement Cost ($/SF) (Sept 2005 Dollars)	Recommended Property Acquisition Cost ($/SF)	Recommended Permanent Easement Cost ($/SF)
Residential-Urban	$22	$7	$26	$8	$45	$14
Residential-Suburban	$10		$12		$36	
Residential-Rural	$5		$6		$30	
Industrial	$15	$3	$18	$4	$23	$7
Commercial	$25	$6	$29	$7	$37	$11

Dewatering cost in Tabula include type of dewatering: trench sump or wellpoints. These costs are based on different ranges of pipe sizes as indicated in the Conveyance System Cost Estimate Report. It should be noted that the dewatering costs shown in the Tabula report vary from the cost backup information contained in appendix A of the Conveyance System

Cost System Pipe Cost Parameters. For comparison, all costs are compared to what is indicated in the text of the report since these are the costs used in the Tabula program.

To calculate costs for trench sump dewatering a daily rate for sump dewatering was calculated. The daily rate is based on 2- 6" diaphragm pumps attended by a laborer operating for 8 hours per day. This daily rate comes from RS Means and is adjusted for King County labor rates. To calculate the cost of dewatering per linear foot the daily production rate of the largest pipe size in each range was used. See the Appendix A for cost information details.

For areas where significant dewatering is expected dewatering costs are based on wellpoint dewatering. The installation and removal of the wellpoint system was taken from RS Means production rates and crews and King County Wage Rates. This cost was then calculated on a per lineal foot of trench basis. The daily operation cost was then divided by the daily pipe production rate to find the lineal foot cost for pump operation. Then the wellpoint installation and removal cost on a per linear foot basis was added to the calculated pump operation lineal foot cost to find the total lineal foot cost for wellpoint dewatering. See the Appendix E for cost information details.

Table 5. Dewatering Costs

Pipe Diameter (in)	Current Tabula Trench Sump Dewatering ($/LF) (Dec 1999 Dollars)	Current Tabula Wellpoint Dewatering ($/LF) (Dec 1999 Dollars)	Escalated Tabula Trench Sump Dewatering ($/LF) (Sept 2005 Dollars)	Escalated Tabula Wellpoint Dewatering ($/LF) (Sept 2005 Dollars)	Recommended Trench Sump Dewatering ($/LF) (Sept 2005 Dollars)	Recommended Wellpoint Dewatering ($/LF) (Sept 2005 Dollars)
8-12	20	50	24	59	20	60
14-21	20	60	24	71	20	65
24-30	20	70	24	82	20	75
36-48	30	80	35	94	30	80
54-60	30	90	35	106	30	95
72-84	40	100	47	118	45	110
96	40	110	47	129	55	125
108-144	40	120	47	141	75	150

Traffic Control cost in Tabula is calculated as either average or heavy. These costs are based on different ranges of pipe sizes as indicated in the Conveyance System Cost Estimate Report. One discrepancy was noted however in the program vs. the cost report. Table 9 in the Conveyance System Cost Estimate Report "Traffic Control" lists incorrect costs for the traffic control used in the program. See Table 6 below. For comparison purposes all cost are compared to the costs used in the Tabula program.

All traffic control costs were calculated using King County Hourly Wage Rates for flaggers. Average traffic control costs were based on one, non-uniformed police, flagger during the entire construction period and two flaggers for heavy traffic areas. A 20% markup was then included to these traffic control labor cost to account for traffic control plans, barrier, signs, temporary stripping, etc. To find the lineal foot cost for flagging a production rate for pipe

placement and surface restoration was established. This production rate was set at half the pipe production rate for pipes under 66″ diameter and at two thirds the pipe production rate for pipes over 66″ diameter in order to account for earthwork and surface restoration costs such as paving. See the Appendix E for cost information details.

Table 6. Traffic Costs Comparison from Report to Actual Tabula Program Costs

Pipe Diameter	Average Traffic Control Cost from Table 9 of Report	Heavy Traffic Control Cost from Table 9 of Report	Actual Average Traffic Control Cost used in Tabula	Actual Average Traffic Control Cost used in Tabula
8-21	$5	$10	$5	$10
24-42	$10	$20	$10	$20
48-66	$12	$24	$15	$30
72-84	$15	$30	$20	$40
96-144	$15	$30	$25	$50

Table 7. Traffic Costs Recommendation

Pipe Diameter (in)	Current Tabula Average Traffic Control Cost ($/LF) (Dec 1999 Dollars)	Current Tabula Heavy Traffic Control Cost ($/LF) (Dec 1999 Dollars)	Escalated Tabula Average Traffic Control Cost ($/LF) (Sept 2005 Dollars)	Escalated Tabula Heavy Traffic Control Cost ($/LF) (Sept 2005 Dollars)	Recommended Average Traffic Control Cost ($/LF) (Sept 2005 Dollars)	Recommended Heavy Traffic Control Cost ($/LF) (Sept 2005 Dollars)
8-21	5	10	6	12	8	16
24-42	10	20	12	24	12	24
48-66	15	30	18	35	18	36
72-84	20	40	24	47	25	50
96-144	25	50	29	59	50	100

Utility conflict is broken into no conflicts, average conflicts and complex conflicts depending on the location of the pipeline. These cost cover utility protections and where necessary utility replacement. See the Appendix E for cost information details.

Table 8. Utility Conflict Costs Recommendation

Pipe Diameter (in)	Current Tabula Average Conflict Cost ($/LF) (Dec 1999 Dollars)	Current Tabula Complex Conflict Cost ($/LF) (Dec 1999 Dollars)	Escalated Tabula Average Conflict Cost ($/LF) (Sept 2005 Dollars)	Escalated Tabula Complex Conflict Cost ($/LF) (Sept 2005 Dollars)	Recommended Average Conflict Cost ($/LF) (Sept 2005 Dollars)	Recommended Complex Conflict Cost ($/LF) (Sept 2005 Dollars
8-12	20	40	24	47	25	45
14-18	30	60	35	71	35	70
20-30	40	80	47	94	45	90
36-42	50	100	59	118	55	115
48-54	60	120	71	141	70	140
60	80	160	94	188	90	185
72-78	100	200	118	235	115	230
84-96	120	240	141	282	140	275
108-144	150	300	176	353	170	345

Section 2: Trenchless Technology

Trenchless technology choices in Tabula consist of microtunnels, bore and jacks, and horizontal directional drilling (HDD). For the fixed input parameters the costs were compared to WSDOT bid tabs, RS Means, and SPU costs. For Right of way costs use the cost recommended in the pipeline costs section. It should be noted that in the current program microtunneling has the excavation and backfill as two separate cost items while bore & jacking combined them into one single cost. In each case the unit cost of $25 per cubic yard was used. This has been changed per Table 9 below. See the Appendix F for cost information details.

Table 9. Trenchless Technology Fixed Input Parameters

Items	Units	Current Tabula Unit Cost (Dec 1999 Dollars)	Escalated Tabula Unit Cost (Sept 2005 Dollars)	Recommended Unit Cost (Sept 2005 Dollars)
Shaft Excavation	CY	$25	$29	$15
Shaft Backfill	CY	$25	$29	$18
Shaft Waste Haul	CY	$25	$29	$12
Combined Excavation & Backfill Cost	CY	$25	$29	$33
Asphalt Paving (Trench)	SY	$50	$59	$40
Existing Utilities (Average)	SF	$6	$7	$7
Existing Utilities (Complex)	SF	$10	$12	$12
Hydroseed	SY	$5	$6	$5

The current Tabula shoring cost formula was compared to RS Means, bid tabs and the recommended cost in the WSDOT bridge design manual. Below is the recommended shoring formula equation.

Current Shoring Cost Equation:

$$\text{Cost (\$/sf)} = \$1.60 \times \text{Depth(ft)} + \$9$$

Recommended Shoring Equation:

$$\text{Cost (\$/sf)} = \$1.85 \times \text{Depth(ft)} + \$10$$

Microtunneling costs were discussed with a local microtunneling contractor. The contractor recommendations were then compared to bid tab information, the existing tabula microtunneling information escalated to August 2005, and a report prepared by Louisiana Tech University on trenchless technology costs. Based on these comparisons a recommended microtunneling cost was established. These recommended costs are shown in Table 10 below. See the Appendix F for cost information details.

For situation where a casing pipe is needed the user selects the carrier pipe diameter size. Tabula will then increase the microtunnel size based on Table 11 to an appropriately sized casing pipe diameter. The casing diameter determines the microtunnel costs used by Tabula. Currently the Tabula September 2001 Conveyance System Cost Estimate Report indicates

that when the user selects a cased pipe they need to go back and calculate the carrier pipe cost separately. This has been changed with the new outputs. The casing material costs an included in the microtunneling costs so there is no need to add any additional cost for the casing material. Instead this was changes so that the program now adds in the additional cost of a carrier pipe to the microtunnel, bore & jack, or HDD costs when using a cased carrier pipe.

The casing carrier pipe costs for microtunnels and bore & jacks are shown in Table 12. For HDD the casing carrier pipe costs are shown in Table 18.

Table 10. Microtunnel Costs

Micro-tunnel ID (in)	Current Tabula MTBM Fixed Cost (Dec 1999 Dollars)	Current Tabula Micro-tunnel Cost ($/inch-diameter/lf) (Dec 1999 Dollars)	Escalated Tabula MTBM Fixed Cost (Sept 2005 Dollars)	Escalated Tabula Micro-tunnel Cost ($/inch-diameter/lf) (Sept 2005 Dollars)	Recommended MTBM Fixed Cost (Sept 2005 Dollars)	Recommended Micro-tunnel Cost ($/inch-diameter/lf) (Sept 2005 Dollars)
12	$90,000	$30	$106,000	$35	$120,000	$40
15	$100,000	$28	$118,000	$33	$130,000	$37
18	$120,000	$27	$141,000	$32	$160,000	$35
21	$140,000	$26	$165,000	$31	$190,000	$32
24	$160,000	$26	$188,000	$31	$210,000	$31
30	$200,000	$25	$235,000	$29	$270,000	$30
36	$250,000	$24	$294,000	$28	$330,000	$29
42	$300,000	$23	$353,000	$27	$400,000	$28
48	$350,000	$22	$411,000	$26	$470,000	$27
54	$400,000	$22	$470,000	$26	$540,000	$27
60	$450,000	$21	$529,000	$25	$600,000	$26
66	$500,000	$20	$588,000	$24	$670,000	$25
72	$550,000	$19	$647,000	$22	$740,000	$25
84	$600,000	$18	$705,000	$21	$800,000	$24

Table 11. Microtunnel and Bore & Jacking Casing Pipe Diameter based on Carrier Pipe Diameter

Carrier Pipe Size (in)	Casing Pipe Size
12	24
15	30
18	30
21	36
24	36
30	42
36	48
42	54
48	60
54	72
60	72
66	84
72	84
84	96
90	108
96	108
108	120
120	144

Table 12. Microtunnel and Bore & Jack Casing Carrier Pipe Material Cost

Carrier Pipe Size (in)	Casing Pipe Size	Current Tabula Casing Pipe Material Cost ($/lf)	Escalated Tabula Casing Pipe Material Cost ($/lf)	Recommended Casing Carrier Pipe Cost ($/LF)
12	24	$30	$35	$50
15	30	$50	$59	$65
18	30	$50	$59	$70
21	36	$60	$71	$90
24	36	$60	$71	$95
30	42	$78	$92	$120
36	48	$105	$123	$145
42	54	$150	$176	$220
48	60	$190	$223	$255
54	72	$240	$282	$285
60	72	$240	$282	$320
66	84	$360	$423	$520
72	84	$360	$423	$570
84	96	$440	$517	$665
90	108	$540	$635	$715
96	108	$540	$635	$760
108	120	$720	$846	$860
120	144	$1,050	$1,234	$1270

The assumption for dewatering made in Tabula is that the shoring system will be watertight thus dewatering will be limited to minor seepage. See the Appendix F for cost information details.

Table 13. Trenchless Technology Dewatering Costs

Number of Shafts	Current Tabula Standard Dewatering (Total $) (Dec 1999 Dollars)	Current Tabula Significant Dewatering (Total $) (Dec 1999 Dollars)	Escalated Tabula Standard Dewatering (Total $) (Sept 2005 Dollars)	Escalated Tabula Significant Dewatering (Total $) (Sept 2005 Dollars)	Recommended Standard Dewatering (Total $) (Sept 2005 Dollars)	Recommended Significant Dewatering (Total $) (Sept 2005 Dollars)
2	$40,000	$60,000	$47,000	$71,000	$50,000	$70,000
3	$45,000	$70,000	$53,000	$82,000	$55,000	$80,000
4	$50,000	$90,000	$59,000	$106,000	$60,000	$105,000
5	$60,000	$100,000	$71,000	$118,000	$70,000	$120,000
5+	$75,000	$120,000	$88,000	$141,000	$90,000	$140,000

Traffic Control for Trenchless Technologies is calculated on a per shaft cost. For purposes of calculating the traffic control the costs are based on two flaggers working over a two month period from the opening to closing up of the shafts. This was arrived at on the basis that the shafts are 1,000 ft apart and the microtunneling production rate is 35 ft/day. Then two weeks are added in for shaft construction and backfill. Finally one additional week is added in for surface/pavement restoration and other miscellaneous sitework. This adds up to 45 days of traffic control labor or two months. In addition a lump sum for barriers, signs, and re-striping are added to the labor cost. See the Appendix F for cost information details.

Table 14. Trenchless Technology Traffic Control Costs

	Current Tabula Traffic Control ($/Shaft) (Dec 1999 Dollars)	Escalated Tabula Traffic Control ($/Shaft) (Sept 2005 Dollars)	Recommended Traffic Control ($/Shaft) (Sept 2005 Dollars)
Standard Traffic	$15,000	$18,000	$20,000
Heavy Traffic	$25,000	$29,000	$35,000

Bore and jack costs were compared with a report published by Louisiana Tech University on trenchless technology costs. These costs were then compared to recent bore & jack bid tab information. Since bore and jacking should take place above the water table Tabula uses a minimal fixed value dewatering cost. Currently this dewatering cost is $7,000 in December 1999 dollar. Based on escalation to September 2005 dollars it is recommended that this dewatering cost be increased to $8,500. See the Appendix F for more cost information details.

Table 15. Bore & Jack Costs

Bore & Jack Casing ID (in)	Current Tabula Bore & Jack Cost ($/inch-diameter/lf) (Dec 1999 Dollars)	Escalated Tabula Bore & Jack Cost ($/inch-diameter/lf) (Sept 2005 Dollars)	Recommended Bore & Jack Cost ($/inch-diameter/lf) (Sept 2005 Dollars)
12	$27	$32	$20
15	$25	$29	$18
18	$24	$28	$17
21	$23	$27	$17
24	$23	$27	$17
30	$22	$26	$18
36	$21	$25	$20
42	$20	$24	$22
48	$20	$24	$22
54	$20	$24	$22
60	$19	$22	$23
66	$19	$22	$23
72	$18	$21	$27
84	$18	$21	$28
90	$17	$20	$28
96	$17	$20	$29
108	$16	$19	$29
120	$16	$19	$30

Horizontal directional drilling costs were compared with a report published by Louisiana Tech University on trenchless technology costs. See the Appendix F for cost information details.

Table 16. Horizontal Directional Drilling Costs

HDD ID (in)	Current Tabula HDD Cost ($/lf) (Dec 1999 Dollars)	Escalated Tabula HDD Cost ($/lf) (Sept 2005 Dollars)	Recommended HDD Cost ($/lf) (Sept 2005 Dollars)
6	$50	$60	$60
12	$150	$180	$180
15	$230	$270	$270
18	$320	$380	$375
21	$400	$470	$470
24	$450	$530	$530
30	$540	$630	$640
36	$640	$750	$750
42	$760	$890	$890
48	$860	$1,010	$1,000

Table 17. Horizontal Directional Drilling Casing Pipe Diameter based on Carrier Pipe Diameter

Carrier Pipe Size (in)	Casing Pipe Size
6	12
12	15
15	18
18	21
21	24
24	30
30	36
36	42
42	48
48	NA

Table 18. Horizontal Directional Drilling Casing Pipe Material Cost

Carrier Pipe Size (in)	Casing Pipe Size	Current Tabula Casing Pipe Material Cost ($/lf)	Escalated Tabula Casing Pipe Material Cost ($/lf)	Recommended Casing Carrier Pipe Cost ($/LF)
6	12	$18	$21	$19
12	15	$26	$31	$31
15	18	$30	$35	$40
18	21	$43	$51	$47
21	24	$43	$51	$58
24	30	$80	$94	$91
30	36	$108	$127	$109
36	42	$140	$165	$127
42	48	$200	$235	$146
48	NA	NA	NA	NA

References

Simicevic, J., Sterling, R. 2003. Survey of Bid Prices for Trenchless Technology Methods. Louisiana Tech University

Section 3: Tunnels

Tunneling costs were discussed with a tunneling contractor to compare the Tabula cost information with current market conditions. These tunneling costs were then compared to bid tabs from recent tunneling jobs. See Appendix G for the tunnel information and cost curves.

Table 19. Tunneling Costs

Tunnel Inside Dia (ft)	Current Tabula TBM Fixed Cost (Dec 1999 Dollars)	Current Tabula Tunnel Cost ($/lf)(Dec 1999 Dollars)	Current Tabula TBM Fixed Cost (Sept 2005 Dollars)	Current Tabula Tunnel Cost ($/lf) (Sept 2005 Dollars)	Recommended TBM Fixed Cost (Sept 2005 Dollars)	Recommended Tunnel Cost ($/lf) (Sept 2005 Dollars)
8	$1,500,000	$2,000	$1,760,000	$2,400	$2,000,000	$2,200
9	$1,800,000	$1,950	$2,120,000	$2,300	$2,500,000	$2,200
10	$2,000,000	$1,950	$2,350,000	$2,300	$2,750,000	$2,200
11	$2,300,000	$2,000	$2,700,000	$2,400	$3,000,000	$2,200
12	$2,500,000	$2,200	$2,940,000	$2,600	$3,500,000	$2,400
13	$2,700,000	$2,400	$3,170,000	$2,800	$3,750,000	$2,600
14	$3,000,000	$2,500	$3,530,000	$2,900	$4,000,000	$2,700
15	$3,300,000	$2,700	$3,880,000	$3,200	$4,500,000	$2,900
16	$3,600,000	$2,900	$4,230,000	$3,400	$5,000,000	$3,200
18	$4,000,000	$3,100	$4,700,000	$3,600	$5,500,000	$3,400

Table 20. Tunneling Dewatering Costs

Tunnel Length (ft)	Current Tabula Standard Dewatering (Total $) (Dec 1999 Dollars)	Current Tabula Significant Dewatering (Total $) (Dec 1999 Dollars)	Escalated Tabula Standard Dewatering (Total $) (Sept 2005 Dollars)	Escalated Tabula Significant Dewatering (Total $) (Sept 2005 Dollars)	Recommended Standard Dewatering (Total $) (Sept 2005 Dollars)	Recommended Significant Dewatering (Total $) (Sept 2005 Dollars)
<1,000	$40,000	$60,000	$47,000	$71,000	$50,000	$70,000
1,000-5,000	$45,000	$70,000	$53,000	$82,000	$55,000	$80,000
5,000-10,000	$50,000	$90,000	$59,000	$106,000	$60,000	$105,000
>10,000	$60,000	$100,000	$71,000	$118,000	$70,000	$120,000

Section 4: Pump Stations

Pumps station cost curves in Tabula were based on several pump station constructed in the late 1990s. The construction costs for the pump station have been escalated using the Seattle ENR CCI index to bring them to current August 2005 dollars. In addition to these cost we have added data points from five other pump stations that were constructed between 2000 and 2005. We have specifically focused much of effort in securing smaller pumps stations to increase the cost curve range and low end accuracy.

One issue we did encounter this that the existing cost curves for Architectural, Sitework, and Mechanical costs were based on the six data points. The report contains the backup information for three of these data point. These are the West Seattle, Interurban and North Creek pump stations. We were unable to find the data relating to the 5, 10, & 60 mgd pumps station used to construct the existing curves. Also the Mechanical cost from North Creek

used to generate the curve is different then the back up information provided and we were unable to verify why this change in the Mechanical cost was made.

Appendix H shows the cost curves and data used to obtain the new recommended pump station cost formula. These costs are construction cost only and do not included allied costs. As a check the new cost curves were then compared to the existing Tabula cost curves adjusted to August 2005 dollars. This was done by escalating the cost component in the existing curve using the Seattle ENR CCI index. This escalated curve output was then compared to the output of the existing curve with the value escalated to August 2005 dollars. Both curves were within 1% of each other so this method was considered valid for escalating the existing curve costs. Appendix H shows the comparison of output of the new recommended curves verse the escalated values of the existing curves.

Below is a summary of the current and recommend cost formulas for the pump stations.

Current Site/Civil Cost:

Site/Civil Cost ($) = $20,000 x Capacity (mgd) + $85,000

Recommended Site/Civil Cost:

Site/Civil Cost ($) = $57,000 x Capacity (mgd) $^{0.90}$

Current Electrical/Instrumentation Cost:

Electrical/Instrumentation Cost ($) = $1,500 x Pump Power (HP) + $314,000

Recommended Electrical/Instrumentation Cost:

Electrical/Instrumentation Cost ($) = $12,000 x Pump Power (HP) $^{0.70}$

Current Site/Civil Cost:

Site/Civil Cost ($) = $20,000 x Capacity (mgd) + $85,000

Recommended Site/Civil Cost:

Site/Civil Cost ($) = $57,000 x Capacity (mgd) $^{0.90}$

Current Architectural/Structural Cost:

Architectural/Structural Cost ($/mgd) = $0.42 x Capacity (mgd)$^{-0.47}$ x 10^6

Recommended Architectural/Structural Cost:

Architectural/Structural Cost ($/mgd) =

$40.29 x Capacity (mgd)^2 - $3,597 x Capacity (mgd) + $206,344

Current Architectural/Structural Adjustment Cost:

Arch/Struct Adjust Cost ($/mgd) =

$0.20 x ((Excavation depth (ft)-30)/30+0.01x(TDH (ft)-120)/120) x 10^6

Recommended Architectural/Structural Adjustment Cost:

Arch/Struct Adjust Cost ($/mgd) =

$0.24 x ((Excavation depth (ft)-30)/30+0.01x(TDH (ft)-120)/120) x 10^6

In addition, it is recommended that the architectural/structural adjustment be limited to no more than a 30% reduction of the base architectural/structural cost. Currently pump stations with high mgd capacities and shallow excavation depths can end up with a negative overall architectural/structural cost. While the base structural cost for pump stations does decrease in the case of shallow excavation there is still a certain cost threshold for the structural cost for the pump stations.

Current Base Mechanical Cost:

Base Mechanical Cost ($/mgd) = $0.33 x Capacity (mgd)$^{-0.43}$ x 10^6

Recommended Base Mechanical Cost:

Base Mechanical Cost ($/mgd) = $261,700 x Capacity (mgd)$^{-0.289}$

Current Mechanical Adjustment Cost:

Mechanical Adjustment Cost ($/mgd) =

$0.05 x ((TDH (ft) – 120)/120) x 10^6 for TDH < 300

1.2 x Base Mechanical Cost ($/mgd) for TDH >= 300

Recommended Mechanical Adjustment Cost:

Mechanical Adjustment Cost ($/mgd) =

$0.06 x ((TDH (ft) – 120)/120) x 10^6 for TDH < 300

1.2 x Base Mechanical Cost ($/mgd) for TDH >= 300

Similar to the architectural/structural adjustment it is recommended that the mechanical adjustment be limited to no more than a 30% reduction of the base mechanical cost. Currently pump stations with high mgd capacities and a low total dynamic head (TDH) can end up with a negative overall mechanical cost. This allows for some decrease in the mechanical cost for pumps stations with a low TDH without overly reducing the base mechanical cost.

Section 5: Storage Facilities

The Storage Facility cost curve in Tabula were based on a number of storage facilities constructed in Michigan in the late 1990's. These costs have been escalated using the ENR CCI index to bring them to current dollars and then adjusted to the Seattle Area using the RS Means regional adjustment factors. In addition to these cost we have added data points from several storage facilities that were constructed in the Seattle area between 2000 and 2005. Using these data points we developed a new curve for the Storage Facilities. See Appendix I for the storage facility cost information and cost curves.

It was determined that the formulas for calculating the dewatering, odor control, and pump stations looked reasonable for this level of estimate and just needed to be adjusted for escalation to September 2005 dollars. With out an in-depth study more accurate costs for these items is not achievable.

One thing to note is that the program uses a different equation than what is indicated in the September 2001 cost write up. We were unable to find any references as to why the Tabula program formula uses a different formula then the cost write up. Below is a summary of the current and recommend cost formulas for the pump stations.

Storage Facility Cost Curve as Indicated in the September 2001 Cost Report:

Storage Facility ($/gallon) = $10.48 x Storage (Mgal)$^{-0.587}$

Storage Facility Cost Curve Actually used in the Tabula Program:

Storage Facility ($/gallon) = $8.96 x Storage (Mgal)$^{-0.448}$

Recommended Storage Facility Cost Curve:

Storage Facility ($/gallon) = $15.02 x Storage (Mgal)$^{-0.621}$

Current Dewatering Costs:

Standard ($) = $750 x (Storage (Mgal))^2 + $36,500 x (Storage (Mgal)) + $340,000

Significant ($) = $1,000 x (Storage (Mgal))^2 + $68,500 x (Storage (Mgal)) + $650,000

Recommended Dewatering Costs:

Standard ($) = $880 x (Storage (Mgal))^2 + $43,000 x (Storage (Mgal)) + $400,000

Significant ($) = $1,175 x (Storage (Mgal))^2 + $80,500 x (Storage (Mgal)) + $765,000

Current Odor Control Cost:

Odor Control Cost ($) = $126,000 x Capacity (Mgal) + $10,000

Recommended Odor Control Cost:

Odor Control Cost ($) = $150,000 x Capacity (Mgal) + $12,000

Current Effluent Pump Station Cost:

Effluent Pump Station ($) = $1.15 x (22,000 x Capacity (Mgal)$^{0.85}$ + 120,000)

Recommended Effluent Pump Station Cost:

$$\text{Effluent Pump Station (\$)} = \$1.35 \times (22{,}000 \times \text{Capacity (Mgal)}^{0.85} + 120{,}000)$$

Appendix A: Fixed Cost Parameters

Appendix B: Pipe Material and Installation Costs

Appendix C: Manhole Costs

Appendix D: Right of Way Acquisition & Easements

Appendix E:
Dewatering, Traffic Control & Utility Conflicts

Appendix F: Trenchless Technology Costs

Appendix G: Tunneling Costs

Appendix H: Pump Station Costs & Curves

Appendix I: Storage Facility Costs & Curves